Translation

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Translation

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Title : A Method for Manufacturing A Semiconductor Device

Specifications

1. Title of the Invention

A Method for Manufacturing A Semiconductor Device

2. Claim

A method for manufacturing a semiconductor device, characterized in that short wave length pulse laser beam is radiated to heat treat a semiconductor thin film.

3. Detailed Description of the Invention

[Field of the Invention]

The present invention relates to a method for manufacturing a semiconductor device such as a thin film transistor (TFT) and so forth.

Translation

[Prior Art and Problems Thereof]

For example, in a transmission type liquid crystal display, a thin film transistor is used as a switching element for turning on/off each picture element. In this case, a great number of thin film transistors are formed on a transparent glass substrate. FIG.1 shows an example of a conventional method for forming thin film transistor on a glass substrate. In the figure, a gate electrode (2) made of aluminum or indium tin oxide (hereinafter ITO) and so forth is first formed on a glass substrate (1) as shown in FIG.1 A, thereafter an SiO_2 film (3), an amorphous silicon hydride (hereinafter a-Si:H) film (4) and an n-type a-Si:H (n^+ -a-Si:H) film for ohmic contact (5) are successively fabricated on the whole surface by use of plasma CVD method. Then, the a-Si:H film (4) and the n^+ -a-Si:H film (5) are patterned, and portions necessary for forming thin film transistors are made into island areas. Thereafter, as shown in FIG.1 B, an Al/Mo2 layer film structure, a source electrode (6) and a drain electrode (7) made of molybdenum, titanium or nichrome or so are formed on source and drain portions. Then, as shown in FIG.1 C, the n^+ -a-Si:H film (5) between the source electrode (6) and the drain electrode (7) is removed by use of plasma etching method and so forth, and leak current between the source and the drain is lost. Thereafter, as shown in FIG.1 D, an SiO_2 layer (8) for passivation and liquid crystal orientation is formed on the whole surface, and further a light blocking layer (9) is formed so as to cover portions corresponding to channel portions, thus a thin film transistor is formed.

Translation

In this method for manufacturing a semiconductor device, at least four masks are required for pattering the gate electrode (2), for forming island areas of the a-Si:H film, for forming patterns of the source and drain electrodes (6) and (7), and further for forming pattern of the light blocking layer (9). And if the film thickness of the a-Si:H film (4) is below about 0.5μm, it is not possible to leave sufficient thickness in the case of etching removal of the n^+ -a-Si:H film (5), and also unevenness in etching process of the n^+ -a-Si:H film (5) and unevenness of accumulation of the a-Si:H film (4) make it difficult to obtain a great number of thin film transistors with uniform characteristics over a wide area, which has been problems with the prior art. And when the a-Si:H film (4) is thick, if the thickness of the source and drain electrodes (6) and (7) is less than around 1μm, stages are apt to cut off.

And in such a thick a-Si:H film (4), since the light transmission degree of a-Si:H is large, the light blocking layer (9) for blocking light is required, which makes manufacturing processes far more complicated. Since the a-Si:H film (4) is hydrated, there are few defects in the film, and in general, on/off ratio 10 6 is to be achieved, and threshold voltage Vth = about 5V may be obtained. However, the film is of amorphous film, the effective movement degree is as small as 0.1 - 0.5 cm^2/VS, as a result, it is not possible to attain a swift switching characteristic.

[Object of the Invention]

Translation

The present invention has been made in consideration of the above problems with the conventional method for manufacturing a semiconductor device according to the prior art, accordingly, one object of the present invention is to provide a method for manufacturing a semiconductor device such as a thin film transistor and so forth, that enables to make the manufacturing procedures easy and simple, and further improve performance.

[Outline of the Invention]

The present invention is a method for manufacturing a semiconductor device, characterized in that short wave length pulse laser beam is radiated to heat treat a semiconductor thin film.

According to the present invention, it is possible to achieve crystallization of semiconductor thin films at low temperature (room temperature) and activation of impurities and so forth without making the whole substrate at high temperature, as a consequence, it is possible to improve performance of semiconductor devices. Also the present invention helps make manufacturing processes far more simple and easy.

[Description of Preferred Embodiments]

In the present invention, a method for manufacturing a semiconductor device such as, for example, a thin film transistor and so forth by making the most of the fact that when short wave length pulse laser is radiated onto a semiconductor thin film to be

crystallized, the laser beam is absorbed only at electrode surfaces of the semiconductor thin film, thereafter the inside of the thin film is melted by heat transmission and is re-crystallized, or annealed, and the crystal particles thereof will become larger.

For example, when an a-Si:H film is used as a semiconductor thin film and XeCl excimer laser beam with wave length 308 nm is radiated thereto, the absorption coefficient to this wave length goes up to 10^8 cm^{-1}, so the excimer laser beam is absorbed into electrode surfaces about 100), and is converted into heat. This heat transmits into the inside of the thin film by heat transmission. In this way, since the surface or inside of the film becomes at high temperature instantaneously, the a-Si:H film is crystallized without discharging hydrogen, and the characteristics thereof are changed significantly. For instance, the movement degree of the film increases greatly, or the light transmission degree is reduced. Or in the film to which ion is implanted, impurities therein are activated.

When a high energy pulse laser beam with such a short wave length is radiated, hydrogen in the a-Si:H film is not discharged, and works to remove dangling bond of crystal particle field even after crystallization.

As short wave length pulse laser beam to be used in the present invention, it is preferable that laser wave length thereof be 100 ~ 400 nm, its practical range be 150 ~ 350 nm, and pulse width below 100 nsec, preferably 10 ~ 50 nsec or 20 nsec. And pulse peak strength is

over 10^6 W/cm^2 and below 10^8 W/cm^2, and fluence (pulse energy per one time) is below 1 J/cm^2, preferably over 50 mJ/cm^2 and below 500 mJ/cm^2, more preferably 200 ~ 500 mJ/cm^2. Use of such a short wave length pulse laser enables local heating.

In the next place, in reference to the attached drawings, preferred embodiments of the present invention are explained in detail. By the way, respective preferred embodiments are cases which are applied to manufacture of a thin film transistor similar to one shown in FIG.1.

FIG.2 shows one preferred embodiment of the present invention. In this preferred embodiment, first a gate electrode (2) made of aluminum or ITO and so forth is formed on a glass substrate (1) as shown in FIG.2 A, thereafter, an SiO_2 film (3), an a-Si:H film (4) and an n^+ -a-Si:H film (5) are successively laminated on the whole surface by use of plasma CVD method. Then, the a-Si:H film (4) and the n^+ -a-Si:H film (5) are patterned, and portions necessary for forming thin film transistors are made into island areas.

Then, as shown in FIG.2 B, a source electrode (6) and a drain electrode (7) made of molybdenum, titanium or nichrome or so are formed thereon, and then with the electrodes (6) and (7) as masks, the n^+ -a-Si:H film (5) on the portion corresponding to channel portion is selectively removed by plasma etching method or so (FIG.2C). The processes hereto are same as those in FIG.1A ~ C.

Translation

Thereafter, as shown in FIG.2D, an SiO_2 film (8) is formed to cover the whole surface, and short wave length pulse laser beam, i.e., UV (ultraviolet) pulse laser beam (10) is radiated from surface side to make poly crystallization or single crystallization of a channel portion (4C) of the a-Si:H film (4), thereby an objective thin film transistor is obtained.

In this method, it is possible to make crystallization of the a-Si:H film of the channel portion (4C) without discharging hydrogen, as a consequence, it is possible to make a large movement degree of a thin film transistor. And light transmission degree is lost by crystallization of the a-Si:H film, and there will be no leak current even when light comes. Therefore, it is possible to omit the conventional light blocking layer (9) that covers the channel portion and the process to mask. Since the UV pulse laser beam (10) goes through the SiO_2 film (8), and is reflected at electrodes (6) and (7), temperature will not rise, and it is possible to process the channel portion without damaging electrodes (6) and (7). For your information, in the case using long wave length laser such as argon laser, YAG laser or so, the temperature of the whole a-Si:H film goes up, and the SiO_2 film (8), and electrodes (6) and (7) and so forth are damaged.

As mentioned above, by local crystallization by laser radiation with electrodes (6) and (7) as masks (by what is called self-alignment), this crystallization can be achieved at room temperature even after accumulation of the a-Si:H film (4) and formation of electrodes (6)

and (7), and without making the film at extremely high temperature. Accordingly, it is possible to simplify the structure of a thin film transistor and the manufacturing processes thereof.

FIG.3 shows other preferred embodiment according to the present invention, applied to a planer type thin film transistor.

In this method, an a-Si:H film (4) and an SiO_2 film (3) are successively formed on a glass substrate (1) as shown in FIG.3 A, and then are patterned into island areas.

Thereafter, a gate electrode (2) made of, for example, titanium, molybdenum or nichrome or so is formed on the SiO_2 film (3) corresponding to a channel portion (4C), and with this gate electrode (2) as a mask, specified impurities such as phosphorus, boron or so are ion implanted to a source portion (4S) and a drain portion (4D) of the a-Si:H film (4).

Thereafter, as shown in FIG.3 B, a source electrode (6) and a drain electrode (7) made of, for example, molybdenum, titanium, nichrome or ITO or so, are formed as to be partially connected to the source and drain portions (4S) and (4D), and then an SiO_2 film (8) are formed thereon. Then, UV pulse laser beam (10) is radiated from the glass substrate (1) side. Thereby, the source and drain portions (4S) and (4D) are activated, and the channel portion (4C) is crystallized.

In this case, if quartz glass or Pyrex glass is used as the glass

substrate (1), laser beam of wave length, for example 308 nm, will go through it, therefore, light is converted into heat at the interface between the a-Si:H film (4) and the glass substrate (1), and the a-Si:H film (4) is heat treated.

In this preferred embodiment, the a-Si:H films of the source and drain portions (4S) and (4D) is crystallized without discharging hydrogen, accordingly, it is possible to make ohmic contact complete, and to carry out activation of impurities sufficiently, and to improve the interface characteristics with the channel portion. Further, it is possible to make the a-Si:H film (4) sufficiently thin, for example film thickness range 100 ~ 1000 is attained, therefore, along with crystallization of the a-Si:H film and thin film thickness, it is possible to remove light transmission degree and to prevent leak current from occurring. Moreover, since it is possible to make the a-Si:H film (4) thin, the stages of source and drain currents will not be cut off.

FIG.4 is still other preferred embodiment of the present invention which is applied to a staggert type thin film transistor.

In this method, as shown in FIG.4 A, a source electrode (6) and a drain electrode (7) made of, for example, molybdenum, titanium, nichrome or ITO are formed on a glass substrate (1), thereafter an a-Si:H film (4) and an SiO_2 film (3) are formed thereon. Further, a gate electrode (2) made of, for example, aluminum or ITO, is formed thereon, and an SiO film (8) is formed on the whole surface of island

areas. And specified impurities such as phosphorus or boron or so are ion implanted into the a-Si:H film corresponding to a source and drain portions (4S) and (4D).

Thereafter, as shown in FIG.4 B, UV pulse laser beam (10) is radiated from two directions of the surface and the glass substrate (1) side, thereby the channel portion (4C) is crystallized, and together with this crystallization of the source and drain portions (4S) and (4D), impurities are activated. In this case, the radiation conditions of the laser beam are changed with the source and drain portions (4S) and (4D) and the channel portion (4C), and respective appropriate conditions are selected.

In this preferred embodiment, since it is possible to respectively select the most appropriate radiation conditions of laser beam to the channel portion (4C) and the source and drain portions (4S) and (4D), accordingly it is possible to improve characteristics further more. And also it is possible to make the film thickness of the a-Si:H film (4) sufficiently thin.

FIG.5 and FIG.6 shows a still other preferred embodiments wherein the process of ion implantation is omitted. FIG.5 is a preferred embodiment which is applied to a reverse staggert type thin film transistor, while FIG.6 is one that is applied to a planer type thin film transistor, and in both the embodiments, a metal that has excellent ohmic characteristics to the a-Si:H film (4) without doping of impurities, for example, nichrome, is used in the source electrode

(6) and the drain electrode (7), and UV pulse laser beam is radiated from two directions, the frontal surface and the rear surface, thereby the channel portion (4C) and the source portion (4S) and the drain portion (4D) are crystallized. In this case, UV radiation conditions (strength, and time) are so selected that the electrode interface should become sufficiently ohmic when UV pulse laser beam (10) is radiated onto the source and drain portions (4S) and (4D). And in some cases, it may be preferable to use the source and drain electrodes (6) and (7) including quinquevalent elements such as, for example, phosphorous (P), arsenic (As), antimony (Sb) and so forth to, and trivalent elements such as aluminum (Al), gallium (Ga) and so forth to p+ type. As the source and drain electrodes (6) and (7), besides nichrome, ITO, molybdenum, titanium and so forth may be employed. In this method, especially since the process of ion implantation of impurities is omitted, the manufacturing processes are simplified further more. The structure in FIG.5 shows one wherein the n^+ -a-Si:H film (5) is omitted in the preferred embodiment in FIG.2, accordingly, it is possible to make the a-Si:H film (4) sufficiently thin in comparison with the case in FIG.2, and for example, it is possible to make as thin as around 200 , and light transmission degree is reduced accordingly, and characteristics are improved far more.

By the way, when to apply the preferred embodiments in FIG.2 through FIG.8, it is necessary to attach an insulation layer for orientation made of SiO_2 or so to the whole surface. If this layer is made at as high a temperature as 300°C, it is not possible to use

aluminum to the source and drain electrodes, however, by use of low temperature process such as deposition or so, it is possible to make a thin film transistor with high performance all by low temperature (room temperature) process except for accumulation of SiO_2 and a-Si:H by plasma.

According to the above preferred embodiments under the present invention, it is possible to make crystallization of a-Si:H film of channel portion at what is called room temperature without discharging hydrogen, and that without making the whole substrate at high temperature, as a result, it is possible to make a large movement degree of a thin film transistor, and also to attain swift switching characteristics.

Further, crystallization of a-Si:H film and thin film thickness thereof enables to make light transmission degree small and to prevent leak current from running even when light is radiated. Accordingly, a light blocking layer can be omitted. And use of high energy, short time, short wave length pulse laser beam enables to make crystallization of a-Si:H film at room temperature, therefore, it is possible to carry out crystallization process after formation of electrodes and formation of passivation film. As a consequence, the structure of a thin film transistor and the manufacturing processes thereof are simplified, and moreover, the yield of production is improved. And further, when the preferred embodiments according to the present invention are applied to the manufacture of thin film

transistor array, it is possible to attain uniform characteristics in respective transistors.

By the way, in the above preferred embodiments, the present invention is applied to the manufacture of thin film transistor (TFT), however, the present invention may be applied also to manufacture of other semiconductor devices using semiconductor thin films.

[Effect of the Invention]

As described heretofore, according to the present invention, by use of short wave length pulse laser beam, it is possible to locally crystallize a non-crystalline or poly crystalline semiconductor thin film, and to activate impurities, and to change the semiconductor thin film into a thin film, for example, one with large movement degree. Further, since this crystallization and activation may be made at what is called room temperature, without making the while substrate at high temperature, it is possible to carry out crystallization and activation processes after the formation of electrodes and the formation of passivation film. As a consequence, when the present invention is applied to, for example, a thin film transistor, it is possible to improve the performance thereof, and also to make the manufacture processes thereof simple and easy.

4. Brief Description of the Drawings

Translation

FIG.1 is a process diagram showing one example of the conventional methods for manufacturing a thin film transistor. FIG.2 is a process diagram showing one preferred embodiment of a method for manufacturing a thin film transistor according to the present invention. FIG.3 through FIG.6 are cross sections showing other preferred embodiments of a method for manufacturing a thin film transistor according to the present invention.

In the figures, the code (1) is a glass substrate, the code (2) is a gate electrode, the code (3) is an SiO_2 film, the code (4) is an a-Si:H film, and the code (5) is an n^+ -a-Si:H film, and the code (6) is a source electrode, the code (7) is a drain electrode, while the code (19) is short wave length pulse laser beam.

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FIG.1 FIG.2 FIG.3 FIG.4 FIG.5 FIG.6